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Coaxial Probe Fed T-Shaped Patch Antenna for Wideband Applications

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Abstract

The aim of this paper is to design a T-shaped patch antenna with coaxial probe feed at appropriate location and compare its bandwidth with conventional microstrip feed line patch antenna. Performance parameters like return loss, VSWR, smith chart are analyzed using HFSS Software v.13. Bandwidth of antenna is found to be enhanced from 0.43GHz to 2.68GHz w.r.t conventional antenna. We have observed that etching slots in patch further improves the S_{11} parameter for return loss from -23.5dB to -72.24dBand minimize the vswr to 1.08. Maintaining compact size of antenna with improved characteristics makes it perfect for wireless applications with high data rate. Details of the antenna design and resulting parameters are presented and discussed.

1. Introduction

Microstrip patch antennas are having wide popularity for use in wireless applications due to their low-profile structure. Therefore they are highly compatible for embedding antennas in handheld wireless devices. Another area where they have been used successfully is in Satellite communication. [9-10]. The popularity for wireless wideband communications is rapidly increasing due to its need to support more users and to provide more information with higher data rates, since the FCC allocated the bandwidth of UWB from 3 GHz to 10 GHz. the maximum achievable data rate or capacity for the ideal band-limited Additive White Gaussian Noise (AWGN) channel is related to the bandwidth and the signal-to-noise ratio through Shannon-Nyquist criterion: $C = B \log_2 (1+ SNR)$; where C is the maximum transmit data rate, B stands for the channel bandwidth, and SNR is signal-to-noise ratio. From this principle, the transmit data rate can be enhanced by increasing either the bandwidth occupation or the transmission power. Main barriers to implement patch antennas in modern wireless communication system applications are their narrow bandwidth. Conventional patch antennas with microstrip feedline are often realized with bandwidth of the order of 1% to 5%. Bandwidth improvement is the alternative to remove this barrier in the patch antennas. Basically the bandwidth is defined more concisely as a percentage (f/ f0) × 100%, where f and f0 respectively represent the width of the range of acceptable frequencies and the central frequency of range of acceptable frequencies of the antenna. The parameters such as return loss and VSWR are often used to define the bandwidth of a microstrip antenna. Broad bandwidth of the antenna may be achieved with selection of appropriate values of design parameters, feed technique that encourage maximum power transfer. [4-7]

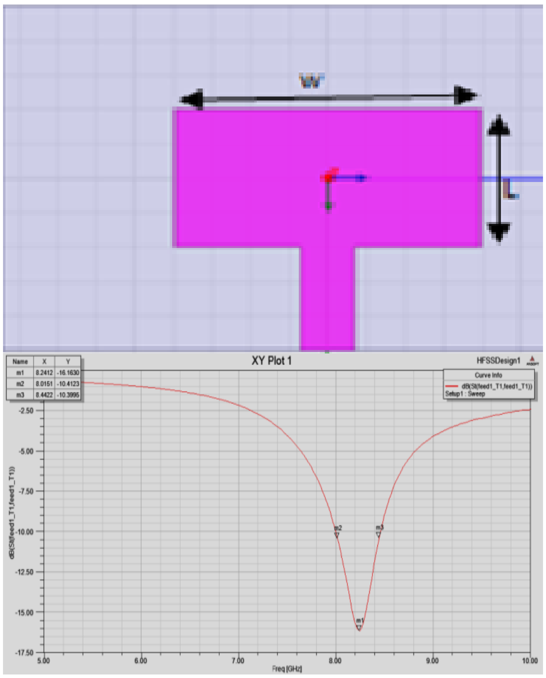

Figure 1 Conventional Microstrip Feedline Antenna (Top) Simulation of Return Loss Parameter (Bottom) {#Antenna1}

2.Antenna Design and Simulation Results

The geometry of conventional microstrip feedline patch antenna is shown in Figure 1 denoted as #Antenna1, and discovered by researchers realizing 0.43 GHz bandwidth. In this paper improvement to #Antenna 1 is done to achieve enhanced bandwidth and maximum impedance matching.

1. Design and Simulation of #Antenna 2

The top and front views of the bandwidth enhanced antenna denoted as #Antenna 2 is shown in Figure 2. After getting the theoretical dimensions of patch antenna optimization process is done to get accurate result as per objective. The optimum feed positions have been determined for good impedance matching. [1].The antenna specifications are given in Table 1.

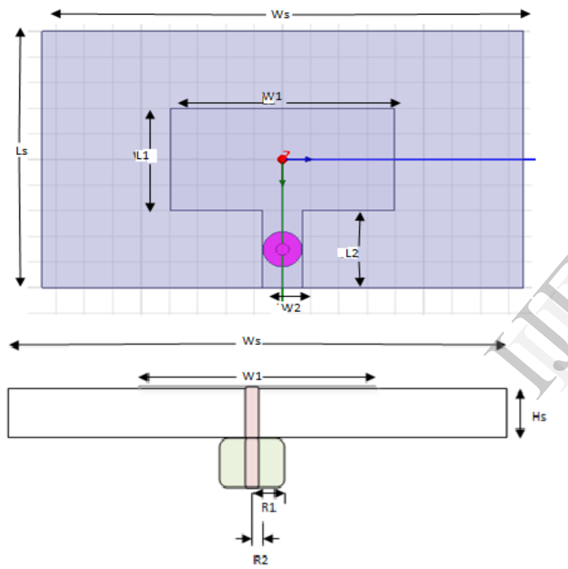

Figure 3 Top view & Front view of #Antenna 2

Table 2 Antenna Specifications

Parameter	Specification
Type of Antenna	T-Shape patch
Dielectric material	FR4 substrate
Dielectric constant	4.4
Operating freq.	8GHz
Feeding method	coaxial probe
Ls	20mm
Ws	34mm
Hs	1.6mm
L1	8mm
W1	15.8mm
L2	6mm
W2	2.8mm
Lg	20mm
Wg	34mm
R1	1.38mm
R2	0.45mm
Probe Location	7 ,0

1. **Return Loss & VSWR**: The operating bands are evaluated by measuring frequencies f_1 and f_2 at either side of the resonant frequency (F_r) with the criterion of return loss S_{11} less than -10dB.

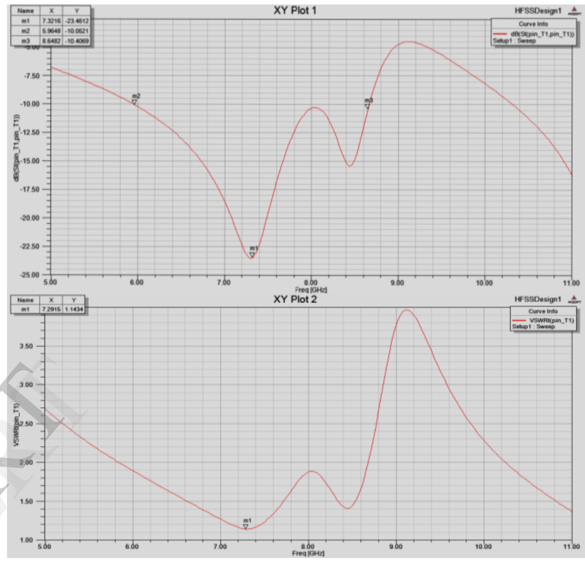

Figure 3 Simulation of Return Loss(top) and VSWR(bottom) of #Antenna 2

The antenna is seen to resonate at F_r = 7.32 GHz very close to the designed frequency, with measured return loss S_{11}= -23.5dB and vswr = 1.1. The frequencies f_1 and f_2 measured corresponds to return loss S_{11}= -10 dB i.e.f_1= 5.96 GHz and f_2 = 8.64 GHz shown respectively in the Figure 3.

2. **Impedance Bandwidth:** The simulated impedance bandwidth for return loss less than -10dB ($|S_{11}| \leq$ -10 dB) and VSWR $\leq$ 2 is found to be BW= 8.64-5.96 = 2.68 GHz. BW (%) = 100*(F_2-F_1)/central frequency i.e. 35.9%.

3. **Smith Chart:** Antenna is matched when the impedance locus is as close as possible to centre of Smith chart that result in a low return loss at the resonant frequency. The antenna is fed by a coaxial probe in order to increase the bandwidth and improve impedance match characteristics.

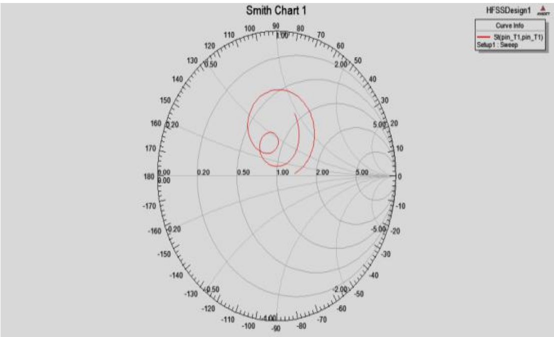

Figure 4 Smith Chart

2. Design and Simulation of #Antenna 3

Above designed antenna is further improved for maximum return loss and minimum vswr. Improved design is denoted by #Antenna 3 as shown in Figure 5.

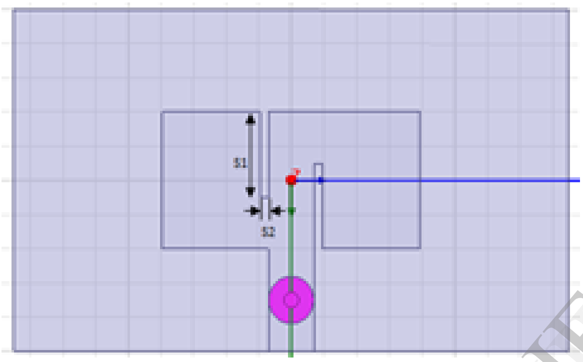

Figure 5 Top view of geometry (#Antenna 3)

Two parallel slots are etched at the locations as shown in the above Figure where S_1=5mm and S_2=0.5mm. VSWR is measure of impedance mismatch between the transmission line and its load. The higher the VSWR, the greater is the mismatch. [2] The minimum VSWR and maximum Return Loss that corresponds to a perfect impedance match is unity and infinity respectively.

1. **Return Loss & VSWR**: The increase in surface wave is correlated by the increase in the return loss S11 and enhancement of the practical antenna bandwidth. S_{11}(Return loss) of simulated antenna is obtained to be -72dB. Value of VSWR indicating a good impedance match is 1.08 which is very much close to 1.

2. **Impedance Bandwidth**: Corresponding f_1 and f_2 is 5.3GHz and 7.8GHz respectively. Bandwidth= 7.77-5.3 = 2.47 GHz. BW (%) =100*(F_2-F_1)/central frequency, Hence impedance bandwidth is calculated to be 37.8%

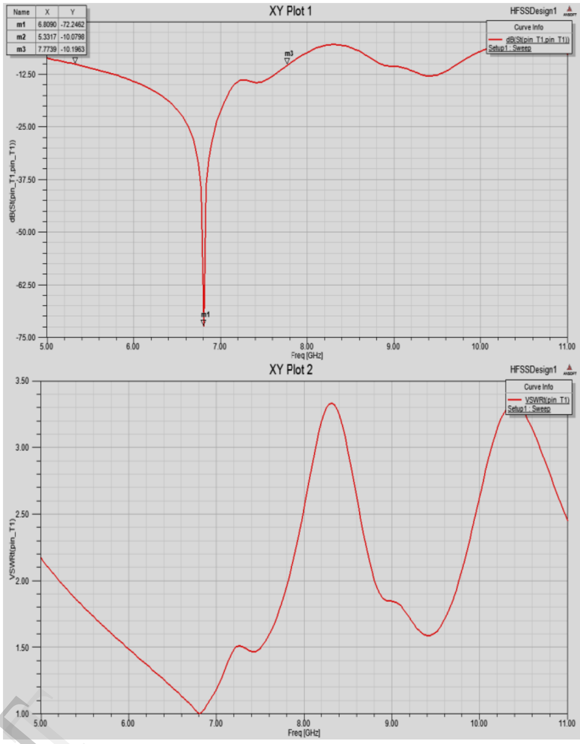

Figure 6 Simulation of Return Loss(top) and VSWR(bottom) of #Antenna 3

3. **Smith Chart:** VSWR = 1 would be the center of the Smith Chart. Simulated smith chart for #antenna 3 shows the smith chart curve is passing very close from the center. Hence minimum power is reflecting from load.

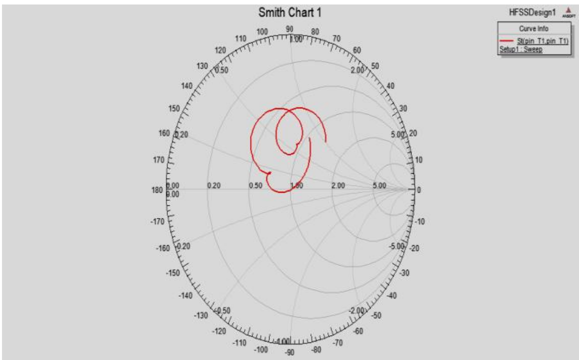

Figure 7 Smith Chart

3. Comparison

Antenna 2 and # Antenna 3 is modification over conventional microstrip antenna which indicates an impressive increase in the impedance bandwidth as

compared to microstrip feed line (#Antenna1). Comparison of antennas is shown in Table 2.

Table 2. Performance Comparison of Antennas

	Return Loss (dB)	Min. VSWR	f1 (GHz)	f2 (GHz)	BW (GHz)	BW %
#Ant.1	-16	1.3	8.015	8.48	0.43	5.20
#Ant.2	-23.5	1.1	5.96	8.64	2.68	35.90
#Ant.3	-72	1.08	5.3	7.8	2.47	37.80

Simulated results show that return loss as well as bandwidth has been improved in proposed antennas. Moreover decrease in vswr for # Antenna 3 is 0.22 from #Antenna 1 which implies that maximum power has been transferred. Increase in impedance bandwidth of proposed antenna is found to be 32.6%. All the modifications are done maintaining the small size of antenna.

4. Conclusion

In this paper we have realized the improvement of bandwidth with minimization of surface wave losses which is due to employing coaxial feeding technique. The bandwidth of proposed antenna resides in the band of UWB specified by FCC for commercial. The simulated and measured results show that the antenna may be used for the application in the wireless field for more information with high data rates. The antenna is designed and simulated using Ansoft HFSS Software for the realization of return loss, smith charts and VSWR. All the modifications of the design were also done on the same software.

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